



# Advisory Circular

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**Subject:** CERTIFICATION OF 30-SECOND AND 2-MINUTE ONE-ENGINE-INOPERATIVE (OEI) RATINGS FOR ROTORCRAFT TURBINE ENGINES

**Date:** 9/6/06

**AC No:** 33-7

**Initiated by:** ANE-111

1. **PURPOSE.** This advisory circular (AC) provides information and guidance on acceptable methods, but not the only methods, for compliance with the requirements for 30-second OEI and 2-minute OEI rotorcraft turbine engine ratings in part 33 of Title 14 of the Code of Federal Regulations (14 CFR Part 33).

2. **APPLICABILITY.**

a. The guidance provided in this document is directed to engine manufacturers, modifiers, foreign regulatory authorities, and Federal Aviation Administration (FAA) engine type certification engineers and their designees.

b. This material is neither mandatory nor regulatory in nature and does not constitute a regulation. It describes acceptable means, but not the only means, for demonstrating compliance with the applicable regulations. We ("the FAA") will consider other methods an applicant may present to demonstrate compliance. Terms such as "should," "shall," "may," and "must" are used only in the sense of ensuring applicability of this particular method of compliance when the method in this document is used. While these guidelines are not mandatory, they are derived from extensive FAA and industry experience in determining compliance with the relevant regulations. If we become aware that following this AC would not result in compliance with the applicable regulations, we will not be bound by this AC, and we may require additional substantiation as the basis for finding compliance.

c. This material does not change, create any additional, authorize changes in, or permit deviations from existing regulatory requirements.

3. **RELATED REGULATIONS AND REFERENCES.**

a. Society of Automotive Engineering, Aerospace Recommended Practice, "Certification Considerations for Highly-Integrated or Complex Aircraft Systems," SAE ARP4754, Section 6, Table 5.

b. AC 33.4-1, Instructions for Continued Airworthiness, Section 10, Guidance for A33.4 – Airworthiness Limitations Section.

c. AC 33.87-1, Calibration Test, Endurance Test and Teardown Inspection for Turbine Engine Certification; Sections 2-3, 3-8, and 4-2.

#### 4. BACKGROUND AND DISCUSSION.

a. The FAA published Amendment 18 to part 33 on June 19, 1996, which incorporated definitions of the 30-second OEI and 2-minute OEI ratings for rotorcraft turbine engines in § 1.1. The amendment also revised specific type certification standards for the ratings in §§ 33.7, 33.29, 33.67, 33.85, 33.87, 33.88, and 33.93. Refer to Appendix 1 for additional background on the history of rulemaking related to these ratings. This AC provides guidance for all sections of part 33 that pertain to the OEI ratings.

b. All OEI ratings are optional ratings intended for executing a safe landing after the failure of one engine of a multiengine rotorcraft; engine manufacturers select OEI ratings from those specified in § 33.7. The table below highlights the different characteristics between the 30-second OEI and 2-minute OEI ratings and OEI ratings of 2½ minutes or longer.

**TABLE 1. DIFFERENCES BETWEEN OEI RATINGS.**

30-second OEI and 2-minute OEI	2½ minutes or longer OEI
Brief period of exposure	Longer period of exposure
Mandatory inspection/maintenance after use	No mandatory inspection required after use
Component and part deterioration may be beyond serviceable limits after their use in one flight	Component and part deterioration are expected to be within serviceable limits after their use
Components or parts may need to be removed from service after their use in one flight	Component and parts remain in service after their use

c. The 30-second OEI rating power provides the rotorcraft with a short burst of very high power to complete the takeoff or to complete a rejected takeoff if one engine fails at the critical decision point (CDP). This power level enables the rotorcraft, at any point at or above CDP, to continue flight, meet obstacle clearance requirements, and gain forward speed for taking off. This power level should also enable the rotorcraft to safely complete a rejected takeoff. If the OEI condition occurs during landing, this high level power should be sufficient to lift the rotorcraft to a safe altitude, clear obstructions in the flight path, and initiate a climb out (balked landing).

d. The 2-minute OEI rating provides adequate power for the rotorcraft to climb out from takeoff or from a balked landing to a safe altitude and airspeed. Once the aircraft has reached this altitude and airspeed, a longer period at a lower power (still equal to or higher than maximum continuous power) is required to continue the flight until a suitable landing site is reached. This power level will be rated maximum continuous, 30-minute OEI, or continuous OEI power, depending on the rating structure of the engine/rotorcraft.

e. The 30-second OEI and 2-minute OEI rating powers allow rotorcraft manufacturers the option of installing a higher rated engine in their products. Benefits for rotorcraft operation with these ratings include:

- Maintaining safety margin for continued takeoff in the event one engine fails or is shutdown;
- Increased payloads while taking off from an existing field or shorter takeoff distance with existing payload; and
- Ability to fly more efficient and profitable routes due to increased residual power which allows the rotorcraft to continue on its flight path if one engine fails.

## 5. GUIDANCE.

a. Section 33.5: Instruction manual for installing and operating the engine.

(1) For rotorcraft engines having 30-second OEI and 2-minute OEI ratings, the applicant should provide in the installation instructions the necessary engine data to assist the installer to comply with the power availability requirements of § 27.45(f) or § 29.45(f). This is to ensure the engine is capable of obtaining and sustaining the OEI rating powers within the associated operating limitations because the power assurance procedures will not include a fuel control topping check to the highest 30-second OEI rating power level due to potential rapid engine hardware deterioration. The data should enable the installer to establish power assurance procedures in which the extrapolation of power assurance results can be achieved from a lower power level to the highest OEI rating power. The performance extrapolation may be accomplished by comparing the performance characteristics with the minimum acceptable engine performance in a deteriorated state. This data should include the effects of installation losses up to and including the highest rating power, such as customer bleed, customer power extraction, and others as appropriate.

(2) The installer should use the engine data to establish a procedure for trending individual engine performance. The data should also be used to support the detection of those latent or dormant conditions of engine systems that are not detectable through power assurance procedures (for example, fuel control maximum flow capability, measured turbine temperature, and speed limits) or that are not detectable because the procedure does not include an engine control topping check to the highest OEI rating power level. The dormant failures, which could lead to non-availability of the rated power of the OEI ratings, should be analyzed, and the results of this review should be part of the data.

(3) The applicant should also provide information on methods to assure that engine limiter settings will not prevent the engine from reaching 30-second or 2-minute OEI power. These engine limiter settings may include engine speed, measured gas temperature, fuel flow, and torque.

b. Section 33.7: Engine ratings and operating limitations – § 33.7(a) and (c).

(1) The 30-second OEI power and 2-minute OEI power ratings are intended to ensure that after one engine fails in a multiengine rotorcraft during takeoff, climb, or landing, the rotorcraft can continue to fly. These are two separate ratings as defined in § 1.1, General definitions. They are used, however, in a 2.5 minute combined period for the operational needs of a rotorcraft. This rating structure consists of 30 seconds at the 30-second OEI power immediately followed by 2 minutes at the 2-minute OEI rating power.

(2) The 30-second and 2-minute OEI ratings were originally conceived as high power ratings using the available margins in the engine design followed by a mandatory engine overhaul. Experience has shown that the manufacturers provide engines that have different capabilities and use different amount of these margins to establish operating limitations. Therefore, some flexibility is possible in defining the mandatory maintenance actions, provided the applicant appropriately validates these actions during certification.

(3) These ratings are intended for use once per flight in an emergency situation. Nevertheless, certification requirements have been defined around the worst-case scenario involving the possible use of these ratings three times in one flight (at takeoff, balked landing, and final landing). We recognize the ratings can also be inadvertently used in unexpected, non-critical conditions, such as an engine failure in a rotorcraft flying at a high-speed cruise. In all cases, the required mandatory maintenance actions apply after any use of the rating powers.

(4) In some circumstances, the highest power used during a 2½-minute duration OEI event might be lower than the 30-second OEI power band, but still within the combined 30-second OEI and 2-minute OEI ratings power band. See paragraph 5.e.(1) of this AC for the rating power band definition. In this case, the applicant may extend the use of the 2-minute OEI rating power to 2½ minutes. However, we will consider the additional 30-second period a derated 30-second OEI rating and the mandatory maintenance actions must follow the requirements in paragraph 5.l.(2)(c).

c. Section 33.14: Start-stop cyclic stress (low cycle fatigue). The requirements of § 33.14 apply equally to 30-second OEI and 2-minute OEI ratings. For rotorcraft engines for which this ratings pair is desired, the applicant should provide a method to account for the low cycle fatigue effects from the use of those two ratings during the life of the engine. This may be accomplished either by reducing an anticipated finite number of cycles from the life of components or by using the appropriate life reduction factor(s) for engine components for each use of the OEI rating power.

d. Section 33.27: Turbine, compressor, fan, and turbosupercharger rotors. The final rule for 30-second OEI and 2-minute OEI ratings (Amendment 33-18, issued on May 30, 1996) did not adopt proposed changes for § 33.27 because the rule for § 33.27 was being harmonized at the time. Therefore, for each application for engine type certification that requests the 30-second OEI and 2-minute OEI rating before the harmonized rule for § 33.27 is issued, the applicant must comply with the existing § 33.27 rule or may request special conditions with appropriate

justifications. See Appendix 2 for the technical content of previously issued special conditions amending § 33.27 that applies to the 30-second OEI and 2-minute OE ratings.

e. Section 33.29: Instrument connection – § 33.29(c).

(1) For compliance with § 33.29(c), the 30-second OEI power level is considered reached whenever one or more of the steady state operating limitations, i.e., power, torque, speed, or gas temperature, that apply to the 2-minute OEI power is exceeded. The 2-minute OEI power level is considered reached whenever one or more of the operating limitations that apply to the next lower OEI rating, or other engine rating, is exceeded.

(2) The engine manufacturer must provide the means to: (1) automatically record the entry into and subsequent use of the 30-second OEI and 2-minute OEI power levels; and (2) automatically alert the pilot to the entry into the power levels, the corresponding impending time expiration, and time expiration point. The automatic recording should be compatible with the maintenance instructions prescribed for these ratings. In particular, it should record the number and time of each usage, or accumulated time, including any exceedence of 30-second OEI and/or 2-minute OEI operating limitations or relevant time limitations. It should also provide a means to alert maintenance personnel that the use of 30-second and/or 2-minute OEI ratings has taken place.

(3) The applicant should ensure that the overall development assurance level of the recording and retrieval system is consistent with its classification of at least hazardous based on failure condition classifications defined in SAE ARP4754. The required overall system assurance level can be achieved based on an appropriate combination of system architecture and component assurance levels. The objectives are to ensure that the information needed for mandatory maintenance is available after the use of OEI powers and to avoid continued operation of the engine in a potentially unsafe condition.

(4) The recording system should be designed so that only maintenance personnel can reset the recording systems. This will prevent further engine operation without mandatory post-flight inspection and maintenance actions.

(5) If the recording or retrieval system is not part of the engine, the engine type certificate holder must specify in the installation instructions the required failure condition classification, system design features, and the interface requirements (for example, reliability, design assurance level, software level, lightning and high intensity radiated fields) for the OEI engine data recording and retrieval system. If software is used for data recording and retrieval, the specifications must comply with the requirements of § 33.28(e).

f. Section 33.67: Fuel system – § 33.67(d).

(1) The flight and operating conditions that require the use of 30-second OEI and 2-minute OEI ratings may create a high crew workload to maintain safe flight. Therefore, the 30-second OEI rating power must be applied and controlled by automatic means that do not require pilot input or control other than a termination command. Once activated, the automatic controls

must increase the engine limiter settings or control the 30-second OEI power and prevent the engine from exceeding its limits. This required automatic control of the 30-second OEI power within its operating limitations is intended to avoid the need for crew monitoring of engine parameters, such as output shaft torque or speed, power, and gas temperature, to avoid exceeding engine operating limits.

(2) The applicant may propose means other than an automatic limiter to satisfy the requirements of § 33.67(d). The engine manufacturer, however, should not put a hard limit on the time limit criteria. This will enable the pilot to respond to emergencies as needed in accordance with § 91.3(b).

(3) The means for automatic control within limits should not prevent the engine from reaching and maintaining its 30-second OEI power.

g. Section 33.83: Vibration test – § 33.83 (b).

(1) When we revised the vibration certification standard in Amendment 17 to part 33, issued on May 29, 1996, the vibration survey requirements for the 30-second OEI rating were addressed in § 33.83(b) under the phrase “all other.” This paragraph states: “The surveys shall cover the ranges...from the minimum rotational speed up to 103 percent of the maximum physical and corrected rotational speed permitted for rating periods of two minutes or longer, and up to 100 percent of all other permitted physical and corrected rotational speeds....”

(2) Section 33.83(b) prescribes the required ranges of power and both the physical and corrected rotational speeds for the vibration survey. For the 2-minute OEI rating, the test speed must be from the minimum rotational speed up to 103 percent of the maximum physical and corrected rotational speed permitted for the rating. For the 30-second OEI rating, the test speed must be from the minimum rotational speed up to 100 percent of the maximum physical and corrected rotational speed permitted for the rating. If there is any indication of a stress peak arising at the highest of those two required physical or corrected rotational speeds, the speed of the survey should be extended sufficiently high to reach the maximum stress values present, except that the speed extension needs to cover only up to 105 percent for the 2-minute OEI rating and 102 percent for the 30-second OEI rating.

h. Section 33.85: Calibration tests – § 33.85(d).

(1) Since rotorcraft engine operation at 30-second OEI and 2-minute OEI ratings could significantly affect engine hardware conditions, these engine rating powers are not required to comply with § 33.85(a), (b), and (c). The calibration test requirements for the 30-second OEI and 2-minute OEI ratings can be satisfactorily substantiated during the endurance test in § 33.87(f) without compromising the purpose of the calibration test. The engine must be capable of producing all rating powers specified in § 33.87(f) without exceeding speed, gas temperature, and other operating limits specified in the type certification data sheets (TCDS).

(2) To properly establish the 30-second OEI and 2-minute OEI rating characteristics, the applicant must consider the effects of engine power deterioration due to both this calibration

test and to the § 33.87(f) testing up to and including the third out of four test sequences of 30-second rated power. Power deterioration through the third test sequence is expected to be the best indicator of the worst-case power deterioration that could occur during actual usage of the rating, and thus should be reflected in the data given to the rotorcraft manufacturer to define performance characteristics of the rotorcraft system. If power deterioration exceeds 10 percent at the 30-second rating during the fourth test sequence, the applicant must evaluate the mode of deterioration. This is to ensure that the availability of 30-second rated power in service will not be compromised by deterioration variability. Any available information from tests in § 33.88(b) or (c) and § 33.90 should also be used to establish the engine characteristics throughout the engine's operating envelope.

i. Section 33.87: Endurance Test – §33.87 (a) and (f).

(1) Under § 33.87(f), the applicant must conduct a 2-hour supplementary test in addition to the basic 150-hour endurance test for rotorcraft engines for which 30-second OEI and 2-minute OEI ratings are desired. The applicant must run the test on the same engine parts after completion of a 150-hour endurance test, except for those parts defined as consumable. We recommend that the applicant disassemble the tested engine and inspect the engine components at the conclusion of the 150-hour test, but prior to the supplementary test, using the criteria specified in § 33.93(a). After completion of the 2-hour supplementary test, the applicant should conduct a second teardown inspection using the criteria specified in § 33.93(b). If the applicant elects not to disassemble and inspect the engine prior to starting the supplemental test, then the teardown inspection requirements of § 33.93(a) apply on completion of the test. The level of component cleaning to facilitate inspection prior to rebuild for the additional 2-hour endurance test must be acceptable to the cognizant Aircraft Certification Office (ACO). The applicant must also show that any cleaning during the teardown inspection, or any replacement of consumable parts, will not enhance the engine's ability to meet the § 33.93(b) requirements of this supplementary test.

(2) The applicant must run four test sequences in § 33.87(f) continuously for the required 2-hour test duration without stopping. In the event of a stop, the interrupted sequence needs to be repeated in full or the sequence can be restarted from the interrupt point if there are technical justifications acceptable to the cognizant ACO. If the ACO determines that the sequence does not need to be repeated in its entirety, then the test should be re-started from a point where the engine thermal condition would be the same as at the time of interruption. If an excessive number of interruptions occur and the severity of the test is compromised, then the applicant may be required to repeat the entire test.

(3) The power level of the test prescribed in § 33.87(f)(4) is to demonstrate the highest en route power: OEI or non-OEI power. During scheduled accelerations and decelerations, the power or thrust control lever should be moved from one extreme position to the other in one second or less. All applicable paragraphs of § 33.87(a), particularly (a)(1) through (a)(6), and (a)(8), must be complied with in running the 2-hour test.

(4) To reduce test complexity, and to improve the flexibility needed to attain the key parameters (speed, temperature and torque) during the test, the cognizant ACO may waive the

maximum air bleed requirement for engine and rotorcraft services under § 33.87(a)(5) if the applicant can show by test, or analysis based on testing, that the engine's ability to meet the teardown inspection requirements of subparagraph § 33.93(b) is not enhanced. The analysis should include (1) the effect of the bleed air extraction on the engine secondary air system which provides cooling air to various engine components; and (2) the thermodynamic cycle effects of bleed (for example, core speed to output shaft speed changes). Similarly, if the power turbine accessory drives are not loaded (as required in § 33.87(a)(6)), the equivalent power must be added to the required power at the output drive so that the power turbine rotor assembly is operated at or above the same level that it would be if the power turbine accessory drives were loaded. The ACO may approve these waivers under the Equivalent Level of Safety authority of § 21.21(b)(1).

(5) The engine operating limitations for 30-second OEI and 2-minute OEI ratings defined in the TCDS must be based on the minimum values obtained during the applications of the 2-hour test of § 33.87(f). Due allowance should be made for stabilization time and the limits of accuracy for instrumentation or automatic controlling systems declared in accordance with § 33.29(c) and § 33.67(d). Refer to AC 33.87-1, paragraph 3-8 of Chapter 3, for additional guidance on conducting endurance tests for these two OEI ratings.

j. Section 33.88: Engine overtemperature test – § 33.88 (b) and (c).

(1) The addition of paragraphs (b) and (c) to § 33.88 in Amendment 33-18 introduced a second overtemperature test requirement for engines seeking 30-second OEI and 2-minute OEI ratings approval. The requirement in § 33.88(b) is to apply the existing overtemperature test conditions to engines without a temperature limiter. For these engines, applicants must run a 5-minute test at 75 degrees F higher than the 30-second OEI rating operating temperature limit and maximum power-on rotor speed. For engines equipped with a temperature limiter (§ 33.88(c)), a 4-minute test run at 35 degrees F higher than the 30-second OEI rating operating temperature limit and maximum power-on rotor speed is an adequate demonstration of temperature life margin of the hot section of the engine. Engines with temperature limiters will need provision for pre-dispatch operational checking for the limiters.

(2) For the purposes of the test, the maximum power-on rpm is the steady state rotor speed associated with the 30-second OEI rating. The applicant, however, should substitute the transient rotor speed for steady state rotor speed if the engine characteristic transient speed stabilization exceeds 3 seconds during the transition to 30-second OEI rating power.

(3) The gas temperature increase for conducting the test (e.g., 75 degrees F in § 33.88(b) or 35 degrees F in § 33.88(c)) is based on the turbine inlet gas temperature at the location immediately in front of the first stage high pressure turbine rotor.

(4) After the overtemperature test, the turbine assembly may exhibit distress beyond serviceable limits provided no burst, blade failure, or other significant failure of any engine component occurs, or becomes evident during the test, shutdown, or the subsequent teardown inspection. If a potential failure becomes evident, the applicant must establish by analysis or test



that the cause would not prevent the OEI rating power from being satisfactorily achieved in service.

k. Section 33.93: Teardown Inspection – § 33.93 (b) and (c).

(1) The concept of limited use ratings followed by mandatory inspection is based on the assumption that some engine parts may not be suitable for further use and may be discarded after these ratings are used. Sections 33.93(b) and (c) therefore provide for a second teardown inspection requirement after the § 33.87(f) test. These sections require the applicant to disassemble and inspect the engine. However, if the applicant does not establish an inspection baseline prior to the testing, then the applicant must comply with the more rigorous inspection standards of § 33.93(a) following the § 33.87(f) test.

(2) After the endurance test of § 33.87(f), the applicant must show that no failure of any significant engine component is evident during the test, shutdown, or subsequent teardown inspection. If a failure is evident, the applicant must establish by test or analysis, or both, that the cause is corrected, or certain limitations are imposed on the engine as appropriate. For the purposes of this section, the engine parts that are deemed significant are those that affect structural integrity, including but not limited to mounts, cases, bearing supports, shafts, and rotor assemblies.

(3) For components that are distressed beyond serviceable limits by this test, the applicant must show that the inspections and mandatory maintenance actions for these components, specified in the Instructions for Continued Airworthiness (ICA), are adequate for maintaining continued airworthiness. The instructions should include means for proper identification of these component conditions and appropriately defined maintenance actions. The component distress seen as a result of the supplementary test of § 33.87(f) should not indicate any potentially hazardous condition. In addition to visible physical damage, applicants should assess non-visible damage—such damage may include, but is not limited to, the effects of creep, stress rupture, metallurgical effects, and life usage. This overall evaluation should be considered when defining and justifying the inspections and mandatory maintenance actions for ICA.

l. Appendix A to part 33, Instructions for Continued Airworthiness – A33.4, Airworthiness Limitation Section.

(1) Mandatory inspection and the associated maintenance actions for any use of the 30-second OEI and 2-minute OEI ratings are required as prescribed in § 1.1, General definitions. Applicants should include inspection and maintenance procedures in the Airworthiness Limitations Section of the ICA.

(2) Inspection and maintenance requirements for rotorcraft engines with 30-second OEI and 2-minute OEI ratings:

(a) Maintenance actions are determined through certification testing including, when applicable, endurance tests, overspeed tests, overtemperature tests, and initial maintenance

tests. These actions are supplemented by results of development testing and service experience of engines of the same or similar design. Servicing information should cover maintenance details regarding servicing points, inspections, adjustments, tests, and replacement of components if required. The mandatory inspection and maintenance actions may also evolve after entering service, based on service experience.

(b) The 30-second OEI and 2-minute OEI ratings are intended to safely use available engine design margins for brief periods of exposure with potential component deterioration beyond serviceable limits and removal from service. The extent of component damage or life reduction caused by the use of the ratings is primarily a function of engine design margins, application exposure level and duration, hardware condition prior to use, and the operating environment. Because engine operation conditions and time recording are requirements for the ratings, maintenance actions can be related directly to documented usage level, time, frequency of usage, and, if applicable, to a known condition prior to rating application (hours/cycles/prior rating exposure, etc.). Depending on the actual operating parameters, such as temperature and time exposure recorded during rating use in accordance with § 33.29(c), predefining a maintenance action and determining the remaining time before overhaul or component replacement is possible, based on the type, level, and duration of exposure. Therefore, mandatory maintenance actions may range from making engine log entries to removal of the engine to a combination of the following:

- 1 Recording parameters and times in maintenance records
- 2 Visual inspection(s) and recording of results
- 3 Power assurance/trend check
- 4 Reduction in time to overhaul or component change
- 5 Addition of special inspection and intervals
- 6 Module change/overhaul
- 7 Engine removal/overhaul

(c) The mandatory inspection and maintenance actions are required following the use of either of these two ratings, or both in one flight, regardless of the frequency of the usage, prior to the next flight. If the 2-minute OEI rating time period is extended to 2½ minutes, the additional 30-second period is considered as a derated 30-second OEI rating, and the maintenance actions prescribed for the 30-second OEI rating should be used. Alternately, the applicant may seek approval for prescribing a different set of inspection and maintenance actions for time exceedence of engine operation at the 2-minute OEI rating. This approval must be appropriately justified and validated. Appendix 3 provides additional guidance on validation of inspection and maintenance actions. If only the accumulated usage time is to be recorded for each rating under § 33.29(c)(3) instead of recording each usage and duration of power at each rating, then the inspection and maintenance actions prescribed by § 33.4 must always be based on the total recorded time duration regardless of the number of times the ratings are used in one flight.

*//signed by Peter A. White for FAF on 9/6/06//*

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## APPENDIX 1. RULEMAKING ON OEI RATINGS

1. The Aerospace Industries Association of America, Inc., (AIA) submitted a petition for rulemaking to the FAA on September 20, 1984, requesting an amendment to part 33 to permit type certification of engines and rotorcraft with new 30-second OEI and 2-minute OEI ratings.
2. As a result of the AIA petition, the FAA issued Notice of Proposed Rulemaking (NPRM) No. 89-27 and Supplemental Notice of Proposed Rulemaking (SNPRM) No. 89-27A, published in the Federal Register on September 22, 1989 (54 FR 39080) and February 7, 1995 (60 FR 7380), respectively. The NPRM proposed definitions and type certification standards for 30-second OEI and 2-minute OEI ratings at higher power levels than those currently available. In response to several comments, the FAA issued the SNPRM, which proposed modified definitions to 30-second OEI and 2-minute OEI ratings and minor wording changes to §§ 33.29, 33.67, and 33.85. The SNPRM also proposed a second overspeed test requirement in § 33.27 for 30-second OEI and 2-minute OEI ratings.
3. The final rule (Amendment 33-18) was published in the Federal Register on June 19, 1996 (61 FR 31324). In the final rule, the FAA adopted the proposed new definitions of 30-second OEI and 2-minute OEI power ratings. The FAA also revised requirements related to OEI ratings in §§ 33.7, 33.29, 33.67, 33.85, 33.87, 33.88, and 33.93. The proposed change to § 33.27 was not adopted because the FAA determined that certain technical aspects had not been resolved and were still under discussion with the Aviation Rulemaking Advisory Committee harmonization working group. The FAA indicated in the final rule that the overspeed test requirements for the ratings would be addressed on a case-by-case basis for each application for type certification that requests 30-second and 2-minute OEI ratings. Four special conditions that addressed overspeed test requirements for 30-second OEI and 2-minute OEI ratings for certain specific engine models were issued between 1993 and 2006.



## APPENDIX 2. EXAMPLE OF SPECIAL CONDITIONS FOR OVERSPEED TEST REQUIREMENTS

1. The following is an example of the technical content of special conditions to § 33.27(b) for the 30-second OEI and 2-minute OEI ratings. For engines with 30-second and 2-minute OEI ratings, in addition to the requirements of § 33.27(b), turbine and compressor rotors must have sufficient strength to withstand the conditions specified in one of the following tests for the most critically stressed rotor component of each turbine and compressor, including integral drum rotors and centrifugal compressor, as determined by analysis or other acceptable means. The selection of the test from the following paragraphs a or b is determined by the speed defined in paragraph a(2) or b(2), whichever is higher.

a. Test for a period of two and one-half minutes—

- (1) At its maximum operating temperature except as provided in § 33.27(c)(2)(iv); and
- (2) At the highest speed determined, in accordance with § 33.27(c)(2)(i) through (iv).
- (3) This test may be performed using a separate test vehicle as desired.

b. Test for a period of 5 minutes—

- (1) At its maximum operating temperature except as provided in § 33.27(c)(2)(iv); and
- (2) At 100 percent of the highest speed that would result from failure of the most critical component of each turbine and compressor or system in a representative installation of the engine when operating at 30-second and 2-minute OEI rating conditions; and
- (3) The test speed must take into account minimum material properties, maximum operating temperature, and the most adverse dimensional tolerances.
- (4) This test may be performed using a separate test vehicle as desired.

Following the test, rotor growth and distress beyond dimensional limits for an overspeed condition is permitted for 30-second and 2-minute OEI ratings only, provided the structural integrity of the rotor is maintained, as shown by a procedure acceptable to the FAA.





### APPENDIX 3. VALIDATION OF MANDATORY POST-FLIGHT INSPECTION AND MAINTENANCE ACTIONS

1. The engine must be maintained in a condition so that the 30-second and 2-minute OEI ratings can be attained and sustained during its service life. The mandatory maintenance following the use of 30-second OEI or 2-minute OEI ratings should be capable of identifying and correcting any component distress that could significantly reduce subsequent engine reliability or prevent the engine from achieving or sustaining further application of the OEI ratings. The applicant should provide evidence by endurance test results, analysis based on test data of the endurance tests, other certification tests, and service experience of engines of similar type and design to show that the powers at 30-second OEI and 2-minute OEI ratings are achievable and can be sustained between overhauls or major maintenance of the engine. The mandatory inspections and maintenance actions may vary depending on engine design. These inspections and maintenance may include some or all of the following actions:

- Recording parameters and times in maintenance records
- Visual inspection(s) and recording results
- Power assurance/trend check(s)
- Reduction in time to overhaul or component changes
- Additional special inspections and inspection intervals
- Module change/overhaul
- Engine removal/overhaul

2. Essential to establishing mandatory maintenance instructions is a thorough knowledge of the potential damage incurred with use of the 30-second OEI and 2-minute OEI ratings and, more importantly, understanding the remaining margin to component failure or reduced engine performance due to use of these OEI ratings. The certification procedures for 30-second OEI and 2-minute OEI ratings emphasize demonstrating design adequacy by endurance testing and by specific margin tests for turbine temperature, rotor speeds, etc. An applicant must have an understanding of operating margins to various failure modes when operating at the 30-second OEI and 2-minute OEI ratings to establish adequate ICA instructions. Applicants should determine and validate these failure modes and margins by appropriate methods or experience that may include but are not limited to:

- Design analytical predictions
- Service experience of identical or similar design
- Actual test or service failure experience
- Results of OEI certification tests
- Dedicated engine and component tests
- Failure Mode and Effect Analysis predictions

3. Understanding of failure modes may come from service experience in which hardware distress or failure was caused by a known exceedence operation. Alternatively, either component or engine level exceedence testing could be useful in evaluating failure mode margins, indications, power decay characteristics and severity. Approaches to establishing failure margins are very design and experience dependent and can vary greatly between engine

### APPENDIX 3. VALIDATION OF MANDATORY POST-FLIGHT INSPECTION AND MAINTENANCE ACTIONS (CONTINUED)

types. One test method that illustrates the objective of failure margin assessment from the 30-second OEI rating condition is to progressively increase engine fuel flow to the point where either an abrupt failure occurs or power begins to decay due to component degradation. Results of such a test could establish margins to, and consequences of, component failure. This could be useful in establishing appropriate maintenance instructions. Potential failure modes are design dependent, however, and most are related to excessive turbine temperature or engine overtorque. Potential failure modes include but are not limited to:

- Blade stress rupture
- Vane distortion/area change
- Case distortion
- Disk, spacer, or seal growth/rub
- Creep
- Incipient melting
- Rub induced high cycle fatigue
- Blade release

4. Mandatory maintenance actions should provide inspection procedures that can reliably ascertain component distress and continued airworthiness, define life reduction, or require component replacement, repair, or overhaul. Applicants with derivative engines with extensive service history can draw upon that experience coupled with OEI testing and failure mode/margin knowledge to establish maintenance requirements with a high degree of confidence. A new type design may have to rely on design/FMEA predictions, development/certification/flight testing, and dedicated failure mode test experience to establish OEI maintenance requirements. These initial requirements could be altered later based upon documented service experience and or additional development tests.